



Description

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METHOD AND APPARATUS FOR DETERMINING RESOURCE CONSUMPTION

- 5 The present invention relates to a method and a apparatus for determining a consumption of resources.

The provision of cold and hot water requires a considerable use of natural resources on the part of both the supply
10 companies and the consumers. The operation of water processing plants, pumping stations and sewage treatment plants and the provision of hot water are especially energy-intensive. Due to water's high specific heat storage capacity of $4.183 \text{ J Kg}^{-1} \text{ K}^{-1}$, large amounts of energy are consumed even
15 for many everyday activities; thus a four-minute hot shower requires 1.5 kWh of heat energy to be supplied, which is usually provided by fossil fuels or electrical energy. In European countries and in North America, the use of water represents a considerable part of primary energy consumption,
20 which entails greenhouse gas emissions and expenses according to today's state of the art.

Despite the growing environmental consciousness, many consumers are insufficiently aware of the connections between
25 water consumption and energy consumption. Water is indeed considered a precious resource by the overwhelming part of the population, but water consumption is only rarely connected to the emission of greenhouse gases and the use of nonrenewable resources, and is thus not included in efforts
30 for climate protection. In addition, consumers lack the possibility of assessing individual withdrawal processes with respect to resource consumption. Monthly or even yearly accounting cycles for utility costs offer only slight



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information about the resource intensity of individual activities; installed water, power, gas, heat and electricity meters likewise allow only insufficient inferences for individual uses. Another disadvantage of the known systems results from the lack of an automatic recognition of related withdrawal processes and the lack of a combination of individual related measurement values with respect to characteristic parameters that characterize finished activities. In addition, the resource consumptions produced by hot water withdrawal are detected at 'multiple measurement points such as the water meter and the gas meter, and would have to be read separately by the consumer, assessed and combined. Combination into easily interpreted characteristic parameters is not possible for most consumers and is too elaborate, especially for short withdrawal processes, such as washing hands. Furthermore, existing systems do not detect the energy expense that must be borne outside the consumer's area of responsibility, such as those for pumping stations. Consequently, behavior is not directly assessed in most cases, and existing systems lead to only marginal changes of behavior.

In addition to their limited functionality, most systems require an external power supply or a battery and are not suitable for installation directly at the point of withdrawal due to their dimensions, particularly if the consumer has high standards with respect to the aesthetics of the installation. An external power supply makes installation in a damp area particularly difficult, while an internal battery is not desirable for environmental aspects.

Documents EP 1308701A2; US 3,342,070; EP 0288448A1; EP 0950877A2; US 5,721,383; US 4,885,943; WO 2008018836 and EP

0990877A2 describe equipment for detecting flow quantities. EP 1858144A2 describes an architecture with improved protection against failure of the power supply. US 6,612,188 shows the utilization of the Wiegand effect as a magnetic
5 sensor in a device for determining a flow quantity. The Wiegand effect requires usage of expensive material and is therefore disadvantageous. EP 1884292A1 describes a measurement device that detects and controls the water consumption at a garden sprinkler or a water faucet.

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A device for determining the quantity of heat transported in a medium is described in DE 102004054118. For this purpose, the device detects the flow quantity of the medium as well as the temperature upstream and downstream of the heat transfer.
15 Measuring the temperature at two points is characteristic for heat quantity measurement devices of this type, which complicates the construction. WO 2007/053091 A1 specifies a device for separate detection of the amount of energy required for service water and for water in radiators.
20 Document GB 2434207 A is concerned with a water and energy costs monitor.

In an application of related devices as consumption information systems at the point of water withdrawal, there
25 are disadvantages among existing devices, particularly due to a lack of mechanisms for recognizing associated withdrawal processes; due to an insufficient possibility for associating consumption information with individual withdrawal processes; due to an inadequate aggregation of measured values into a
30 characteristic parameter characterizing the withdrawal process; due to a lack of information on the greenhouse gas emissions produced by the withdrawal; due to a high installation-related expense for determining the water

temperature upstream of the water processing to determine the amount of expended thermal energy; due to the spatial separation between display and point of user interaction or the controller of the water withdrawal; due to the lack of application-related and situation-related information to assess behavior; as well as due to the use of expensive devices for energy supply.

The invention can be based among other things on the problem of acquiring resource consumption including water consumption, energy consumption for preparing hot water, expenses for pumping etc. for withdrawal processes of hot or cold water, of allocating this consumption to individual withdrawal processes, determining the resulting characteristic parameters with respect to costs and environmental influences such as water volumes, energy amounts, greenhouse gas emissions etc., and visualizing them at the point of withdrawal or the point of control of such a withdrawal process and supporting the assessment of the user's own behavior, as well as creating incentives for an environmentally protective and cost-saving behavior. In addition, the invention is based on the problem of developing a device that requires no external power supply or external sensors in order to reduce the expense for installation, as well as being easily integrated with respect to overall size and shape, including aesthetic aspects, into existing installations such as those in the kitchen at the sink faucet, and in the bathroom at the washbasin, bathtub or shower faucet.

The object of the invention is to provide a method and a device in order to detect resource consumption inexpensively.

This object is solved with the method according to Claim 1 and the arrangement with the features of Claim 22. Refinements and configurations are the subject matter of the dependent claims.

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The invention described below simplifies the measurement, determination and display of information on the use of hot and cold water that supports or motivates the consumer to reduce the resource consumption caused by water usage, as well as the associated emission of greenhouse gases. This information comprises, alone or in combination, data on costs incurred, consumed water volumes, required energy amounts, greenhouse gases produced, as well as information for comparison with similar user groups and the presentation of trends with respect to consumption behavior. Information is acquired and displayed both continuously during the water withdrawal and in aggregated form for related withdrawal processes. The display takes place in the direct spatial vicinity of the device controlling the withdrawal, i.e. the water faucet in the kitchen, the bath or garden, the shower head or the shower hose, the mixing tap, etc.

For this purpose, the device measures the flow quantity and the temperature of the fluid. A turbine wheel that is manufactured from magnetized material or mechanically connected to one or more permanent magnets is used to determine the flow quantity. In case of a withdrawal of water, the turbine wheel is set into rotational movement and generates an alternating magnetic field in one or more coils. The characteristic curve of the resulting voltage serves as an indicator of the rotational frequency and, after conversion, the flow quantity. The induced voltage can additionally be used as an energy source for the device,

which makes it possible to dispense with a battery or large storage capacitors. The quantity of heat expended for heating the water is determined on the basis of an individual temperature sensor and a microcontroller, both housed in the device, and a method described below for estimating the water temperature prior to heating. The costs and environment-relevant parameters ascribable to the withdrawal are calculated by an evaluation of the expended amount of energy, taking into account, if necessary, the type of energy conversion such as using electrical energy versus direct usage of fossil fuels versus solar collectors, as well as an assessment of the withdrawn amount of water, also taking into account for the calculation of the greenhouse gas emissions the emissions that arise in the provision of cold water or the disposal of wastewater, for utility companies for instance. The factors necessary for this are stored in the microcontroller's memory.

The grouping of individual water withdrawals into related withdrawal processes is done with the aid of a microcontroller by evaluating the duration of individual water withdrawals and the time intervals between two or more than two withdrawals. When a turbine wheel is used for power generation, there is sometimes not enough energy available between two withdrawal processes to operate a low-cost timer. In this case, the measured temperature change from just before the switch-off until the next switch-on can serve as the time basis; alternatively, the voltage difference at a capacitor can be used for evaluation. The above-specified consumption information can be displayed in aggregated form for related withdrawal processes and therefore requires no calculation by the user. As an example, the brief opening of the water faucet to moisten a toothbrush and the reopening

for rinsing the mouth and cleaning the toothbrush would be combined into one withdrawal process, but washing hands half an hour later would be a new measurement, with a reset water meter for example.

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Frequently, not all acquired consumption information is of interest, or only a selection could be displayed for technical reasons. In this case, the information of interest of the user can frequently be derived from the course over
10 time of the flow quantity and the temperature. The device recognizes characteristic curves of measurement parameters, ascribes them to the most probable context, such as hand-washing, showering, watering the garden, metering water, etc., and selects the display mode defined for this context.
15 Thus for instance, a slow reduction of the fluid flow after an abrupt opening of a valve, "switch-on process," can be inferred as a metered process in which the volume of the fluid withdrawn since the abrupt switch-on event is very probably of primary interest, for which reason information on
20 this withdrawn water amount is preferably displayed.

If needed, the device can be further equipped with a communication interface and a nonvolatile data memory.

25 In one embodiment of a method for determining a signal indicating the resource consumption, a fluid quantity is determined for a fluid that is withdrawn at a withdrawal site during a withdrawal unit. The signal indicating the resource consumption is determined as a function of the amount of
30 fluid determined during the withdrawal unit.

In one embodiment, a temperature of the withdrawn fluid is determined as the actual temperature. The signal indicating

the resource consumption can be determined as a function of the amount of fluid determined during the withdrawal unit and additionally as a function of the actual temperature determined during the withdrawal unit.

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The fluid can comprise water.

Alternatively, the resource consumption value can be determined from the difference between the actual temperature and a base temperature.

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The actual temperature value can be determined per time unit. The signal indicating the resource consumption can be determined as a function of the amount of fluid determined during the withdrawal unit and the actual temperature per time unit determined during the withdrawal unit.

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A withdrawal unit can be an individual withdrawal process.

Alternatively, a withdrawal unit can be an individual withdrawal process or, if the individual withdrawal processes take place in a time interval that is smaller than a predetermined time window, an overall withdrawal process that is composed of several individual withdrawal processes. The amount of fluid can be the amount of fluid of the individual withdrawal process or the amount of fluid of the overall withdrawal process.

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In one embodiment, an arrangement for determining the resource consumption comprises a generator for generating an output voltage by means of the fluid, in particular water, flowing through the arrangement during a withdrawal unit, and an electronics component. The electronics component can be

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designed to determine an amount of fluid of the fluid flowing through the arrangement during the withdrawal unit from the output voltage of the generator, and to provide a signal indicating the resource consumption as a function of the
5 output voltage of the generator.

In one embodiment, the electronics component is designed to base the withdrawal unit on an overall withdrawal process composed of several individual withdrawal processes if the
10 individual withdrawal processes take place during a time interval that is smaller than a predetermined time window.

The time window can be a time t with $t \leq t_2$, where a time duration t_2 is determined from the group comprising the
15 average duration of tooth brushing, the average duration of hair washing and the average duration of lathering up.

A time t with $1 \text{ sec} \leq t \leq 5 \text{ min}$ can be defined as the time window.

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In one embodiment, the fluid flowing through the arrangement during a withdrawal unit is subsequently withdrawn at the withdrawal site. The withdrawal site is downstream of the arrangement.

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In one embodiment, the arrangement comprises a temperature sensor for emitting a temperature signal that depends on a temperature of the fluid. The electronics component is designed to provide a signal indicating the resource
30 consumption as a function of the temperature signal and the output voltage of the generator.

In one embodiment, the electronics component is designed to provide the signal indicating the resource consumption also as a function of a base temperature. A measured lowest temperature during a number M of previous individual withdrawal processes, or a base value is defined as the base temperature.

The electronics component can comprise a microcontroller. The microcontroller can be designed to combine individual withdrawal processes into an overall withdrawal process by means of an evaluation of a duration of individual withdrawal processes and the time intervals between two or more individual withdrawal processes.

In one embodiment, the generator is designed to generate the output voltage of the generator in such a manner that the output voltage of the generator can operate the electronics component.

In a refinement, the generator comprises a turbine wheel that is designed to be set into rotational motion by the fluid flowing through the arrangement.

The turbine wheel can be produced from magnetized material. Alternatively, the turbine wheel can be connected to at least one magnet. The at least one magnet can be situated in the fluid.

The arrangement can further comprise an interior housing. The generator can comprise at least one coil. The at least one coil can be mounted on a side of the interior housing facing away from the fluid in such a manner that an alternating magnetic field flows through the at least one coil during the

rotational movement. The turbine wheel can be arranged together with the at least one magnet in the interior of the interior housing and fluid can flow around it.

- 5 In one embodiment, the arrangement comprises a housing. The housing can have a thread or a coupler that is designed for connection to a water faucet, a shower head, a shower hose, a mixing tap, a water line, or a garden hose.
- 10 In one embodiment, the arrangement can comprise a display module. The display module is used to display the signal indicating the resource consumption.

In a refinement, the arrangement comprises a rectifier module
15 for generating a supply voltage from the output voltage of the generator. The at least one coil can be connected to the rectifier module.

A water withdrawal device, in particular a faucet, a shower
20 head, a shower hose, a mixing tap, a garden hose or a water line, can comprise an arrangement for determining the resource consumption.

In one embodiment, the arrangement for determining the
25 resource consumption is constructed as a device.

The invention will be described below for several exemplary embodiments with reference to the figures; individual modules or functional units are described, wherein a shift of
30 components or functions into other modules is implicitly included in the description. Areas and structures with identical function or effect bear identical reference numbers. Therein:

Figure 1 shows an example of a schematic structure of a device or a described method, with integrated display,

- 5 Figure 2 shows another example schematic structure of the device or the described method, with a separate display,

Figure 3 shows an example of a rotor functioning as a sensor and generator of the described device or the described
10 method,

Figure 4 shows a block diagram of an example of the device or the method described in Figure 1 with an integrated display,

- 15 Figure 5 shows a block diagram of an example of the device or the method described in Figure 2 with a separate display,

Figure 6 shows an example of a possible circuit diagram of the rectifier module, with the optional optical communication
20 configuration of the device or method described in Figure 1,

Figure 7 shows an example of a possible circuit diagram of the electronics for the rectifier module and the optical transmission of the measured information to a separate
25 device,

Figure 8 shows several exemplary water withdrawals and their grouping into combined withdrawal processes, and

- 30 Figure 9 shows exemplary measurement processes, their grouping into combined removal processes and the resulting display mode.

As sketched in Figures 1-5, the device or the method can be described by means of the cooperation of a generator 11, whose output voltage is used both as an indicator of the flow quantity and for supplying a voltage to the electronics components; a temperature sensor 12, a rectifier module 13 with smoothing capacitors and elements for protection from overvoltage, a microcontroller 16; an internal or external display module 14; and an interior and exterior housing 151 and 152 with, in addition to other components, a screen 153, an optional water stream regulator 154, as well as an optional flow regulator 155.

The generator 11 consists of a rotor/turbine wheel 111 that is set into a rotational motion by the water flowing through the device; in a preferred configuration, the water is deflected via one or more channels 10 in such a manner that it flows tangentially onto the turbine wheel 111, see Figure 3 in particular; alternatively, a turbine wheel 111 can be used onto which water flows parallel to the axis. The turbine wheel comprises a shaft 7, 8. The turbine wheel 111 is seated with low friction, preferably with the aid of a slide bearing 9. In a preferred configuration, the rotor is either itself magnetized diametrically or sectorally, or is mechanically connected to corresponding permanent magnets 113. One or more coils 114 are mounted on the outer side of the interior housing 151, so that an alternating magnetic field flows through them in case of a rotational motion of the rotor. In a design in which the rotor consists of n pole pairs or is connected to a magnet 113 that consists of n pole pairs, $2n$ coils 114 are preferably mounted such that the induced voltages of the individual coils 114 can be added up to a $2n$ -fold voltage in a series connection. The generator 11 is designed such that, even for low flow amounts, a voltage that

is high enough to operate the electronics components is generated.

5 The temperature sensor 12, preferably an analog PTC or NTC or an integrated circuit with analog or digital output, is mounted in such a manner that the temperature of the medium can be determined without delay to the extent possible.

10 The rectifier module 13 consists of one or more diodes with low-voltage loss D2, D32, D34, preferably Schottky diodes, and one or more smoothing capacitors C1, C31, C32. Also see Figures 6 and 7. As already mentioned, the generator 11 is designed in such a manner that the generated voltage is higher than the highest minimum supply voltage of the
15 electronic components, even for low flow quantities. For high flow quantities, this results in a supply voltage VDD that can damage the electronic components. For protection from overvoltage, diodes with an on-state voltage greater than the minimum supply voltage and less than the maximum desired
20 supply voltage are inserted upstream of the rectifier diodes D2, D32, D34; in a preferred configuration, the diodes are light-emitting diodes D3, abbreviated LEDs, with which the later-described display 14 is illuminated or with the aid of which the water stream 141 is illuminated. Alternatively,
25 Zener diodes D33 can be used. For the above-described usage of light illuminating diodes D3 upstream of the rectifier diodes D2, the internal resistance of the generator 11 replaces an additional current limiter. In addition to the supply voltage VDD, the rectifier module 13 provides a signal
30 from which the rotational frequency of the generator 11 can be derived. If an external display module 14 is used, see Figures 2 and 5 in particular, rectification is done according to Figure 7, wherein one half-wave of the generator

11 is used to supply a transmission device or transmission module 18, and the other half-wave is used for supplying, in particular, the digital logic unit MC31 or 16, 17. The advantage of this is a higher efficiency as well as the possibility of supplying the logic unit and the transmission unit 18 with different voltage levels. The rectifier module 13 in accordance with Figure 7 comprises an IR transmitter 130. The digital logic unit MC31 is implemented as a microcontroller MC31.

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The rectifier module 13 in accordance with Figure 6 comprises an additional diode D1. The rectifier 13 has a digital logic unit MC1. The digital logic unit MC1 is implemented as a microcontroller. A transistor T1 is driven by the digital logic unit MC1 via a resistor R1.

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A numeric, alphanumeric or dot matrix liquid crystal or light emitting diode display is used as the internal or external display module 14. Lighting or backlighting 141 increases the reading convenience and, for an internal display module 14, simultaneously serves as an overvoltage protector. According to Figure 2, the external display module 14 comprises a receiver unit 145 and a display 142. The external display module 14 can comprise a digital logic unit 146. The external display module 14 can comprise an additional user input 168.

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The housing 151, 152 contains the electronic and mechanical components and optionally offers a mount or view window for the display 142. The housing is also constructed in such a manner that it protects the electronic components from contact with water. The housing, preferably the interior part 151, is equipped with a device such as a thread or a coupler that enables easy connection to a water faucet, a shower

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head, a shower hose or a garden hose. In a preferred configuration of the variant with an external display module 14, the measurement module, see Figure 2 at the top, replaces the conventional water stream regulator of a water faucet.

5 The water-conducting interior part of the housing 151 contains a screen 153 with which the rotating parts are protected from contamination. An optional water stream regulator 154 can be mounted at the water outlet of the device. A flow limiter 155 can also be mounted, which further
10 increases the savings effect of the device, as well as protects the device from excessively large flow quantities.

A mounting position of the device shown in Figures 1 and 2 can be on a water faucet, for example. The device shown in
15 Figure 2 can be used as a replacement for a conventional water stream regulator.

The microcontroller 16 can be subdivided into several functional modules, including a module 161 for measuring the
20 flow quantity, a module 162 for temperature measurement, a module 163 for estimating the expended energy quantity; a module 164 for management of the display, a data memory 165, a module for power management 166, a module 167 for management of the data communications 167, a module 168 for
25 detecting and evaluating user inputs, as well as a module 169 for recognizing related withdrawal processes, wherein individual functions can also be subdivided in a different manner between the modules, and individual modules can be combined into larger functional units.

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The module 161 for measuring the flow quantity determines the rotational frequency of the generator 11 and calculates therefrom the quantity of water that flows through the device

per time unit. Indicators of the rotational frequency are the generated voltage and the frequency of the voltage. To determine the frequency of the voltage, the time difference is determined between two polarity changes or zero-crossing points for a defined edge, or between falling below and exceeding a defined voltage for a defined edge. This can be done with the aid of a comparator, a logic input or an analog-digital converter. Alternatively, the signal can be acquired with an analog-digital converter and its digital representation evaluated using pattern recognition. The frequency is translated into the flow quantity per time unit V_{unit} with a device-specific multiplier, primarily as a function of the selected channel width 4 and the configuration of the turbine wheel 111, as well as a possible bypass for application fields with high flow quantities. The successive values of V_{unit} are summed up over the withdrawal period and provided as a volume per withdrawal process V_{ext} . To improve the measurement precision, the inertia of the rotor can be compensated by an offset value and nonlinearities can be reduced with the aid of the respective characteristic curves.

The water temperature at the outlet of the device is acquired with the aid of a temperature sensor 12 and evaluated with the temperature module 162. The temperature sensor 12 supplies either an analog value digitized by an analog-digital converter, or a digital representation of the measurement value. The temperature module 162 supplies the digital value of the current temperature T_{act} as well as the minimum value T_{min} during the most recent M withdrawal processes, where M is an application-specific constant between 8 and 1024. T_{min} is set on delivery or after a reset to an application-specific value between 4°C and 20°C. T_{min}

is used to estimate the water temperature before heating, under the assumption that at least one withdrawal process of cold water occurred during M withdrawal processes. A more precise determination of the heat quantity is possible with
5 this structure, without having to integrate a sensor in the cold water reservoir. The temperature module 162 can be calibrated in a defined environment during programming of the device. Alternatively, a base value for T_{min} can be determined, such as the mean temperature that water has when
10 fed to a supply network.

The module 163 for acquiring the energy quantity accesses the module 161 for measuring the volume and the temperature module 162 in order to estimate the heat quantity that was
15 supplied for the provision of the hot water. For this purpose, the quantity of water flowing to each device during a water withdrawal per time unit V_{unit} is multiplied by the difference between the temperature measured in this interval T_{act} and T_{min} , and the individual products are summed up
20 and are multiplied by the specific heat storage capacity for water. The heat quantity supplied per withdrawal process E_{ext} is corrected if necessary by an assumed efficiency of the heat exchanger as well as by the heat losses during water transport. Heat losses during transport of water can be taken
25 into account by addition of a value that results from the water temperature at the end of the withdrawal process of the withdrawn quantity of water until the water temperature at the beginning of the withdrawal process is reached and the specific heat capacity of water, which corresponds to an
30 approximation of the quantity of heat remaining in the pipe system. The efficiency of the heat exchanger is taken into account by multiplication by a value greater than one. The quantity of heat expended E_{ext} can be expressed in watt

hours, kilowatt hours or some other unit for energy. E_{ext} and V_{ext} can be further used to estimate the resulting greenhouse gas emissions for a withdrawal process. For this purpose, E_{ext} is multiplied by a constant that describes the emission per energy quantity, for example in grams of carbon dioxide equivalent per kilowatt hour, of a system for providing hot water (for an average system on delivery and adaptation to oil heating, solar collectors, etc. if necessary) and is added to the product of V_{ext} and the average emission per volume unit for providing cold water. The energy quantity E_{ext} can be supplemented with the quantity of energy for providing drinking water, in particular, by adding the product of V_{ext} and the average quantity of energy per volume unit for providing cold water. The costs per water withdrawal can be specified via an addition of the product of the quantity of heat energy for the withdrawal and the specific energy costs, as well as the product of the withdrawn water volume and the costs for fresh water and wastewater.

The module 164 for controlling the display uses the results of the module 161 for measuring the volume, the temperature module 162, the module 163 for determining the energy quantity, in particular, including costs and emission data, or a combination thereof in order to represent the implications of the ongoing or recently finished withdrawal process. The module 164 can alternate between two or more measured values or can represent one measured variable preferably or exclusively. The preferred displayed measured variable can be preset or can be selected automatically via a recognition of the relevant application. The instantaneous flow quantity and the water temperature in particular are used as an indicator for this; the display of the heat

quantity can be omitted if only cold water is withdrawn, for example; if the water flow is slowly reduced by the user, this can be inferred to be a metered process and the variable describing the removed volume is preferably displayed, see
5 Figure 9.

The memory module 165 preferably consists of a nonvolatile data memory that is integrated into the microcontroller 16. The module 165 is used to determine the minimum water
10 temperature T_{min} of the most recent M withdrawal processes and to save it. In addition, T_{act} , V_{ext} , and E_{ext} are stored. The average values and accumulated measured variables from several preceding measurement periods can likewise be stored in order to detect trends in the user behavior. The
15 memory module 165 can also store the program variables. For more elaborate evaluation methods, data on the individual withdrawal processes can also be stored. If it is advantageous for the construction, the memory module 165 can also be integrated as an external component.

20 The module for power management 166 recognizes critical states of the supply voltage VDD, for example, because of an excessively low rotational frequency of the generator 11 and consequently an expected discharge of the smoothing
25 capacitors C1, C31, C32. In this case, the module 166 initiates a backup of the program variables and the current measured values in the memory module 165, brings the microcontroller 16 into a defined state and ensures the recovery of the operating state after the voltage goes back
30 up.

The communication module 167, optional for an internal display module 14, is used as a data interface to an external

device, which enables a more comprehensive storage,
evaluation and display of the consumption data, if required.
Possible transmission technologies include optical or radio
frequency-based methods, in which data are transferred via
5 amplitude shift keying, abbreviated ASK, differential phase
shift keying, abbreviated DPSK, on-off keying, abbreviated
OOK, or combined modulation techniques. In a preferred
configuration, the backlighting 141 serves as a transmitter,
wherein the communication module 167 of the microcontroller
10 16 performs a modulation if the generator voltage in the
forward direction is greater than the on-state voltage of the
LED D3. In order to maximize the on-time of the diode D3, the
diode D3 is switched on and off with the aid of a parallel-
connected transistor T1 rather than one connected in series,
15 see Figure 6.

Figure 6 shows a possible circuit diagram of the rectifier
module for the device described in Figure 1 or the described
method with the optional configuration for optical data
20 transmission. In place of the diode D3, two LEDs can
optionally be employed to utilize both half-waves and to
protect against excessively high off-state voltages. The
diode D2 can optionally be replaced by a bridge rectifier.

25 The optional user input module 168 makes it possible to
define or select given parameters and thus to improve the
accuracy of the measurements and calculations. The user can
thus select the heat source used to prepare hot water, in
particular, oil heating, gas heating, electrical
30 instantaneous water heaters, solar collectors etc. and
determine the parameters with respect to emission data and
costs. The costs for fresh water and wastewater can also be
input. It is further possible under certain circumstances to

select desired display modes or defined units of the measured variables, or to bring the device into the state set upon delivery, "reset." The input module 168 can likewise be used to calibrate the device, particularly the modules for
5 temperature and flow measurement 161, 162. The user input mode can be activated via a defined sequence of short and long water withdrawals, "sequences." If the user input mode is activated, individual parameters or menu options can be selected and modified via defined sequences.

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The module 169 for recognizing related withdrawal processes recognizes and combines water withdrawals that very probably belong to one withdrawal process, or initiates new measurements for water withdrawals that should very probably
15 be ascribed to new withdrawal processes. This makes it possible to automatically assign measurements to individual activities or work steps of a user and to prepare the results in such a manner that no calculations by the user are necessary, which increases the perceived value of the
20 information. For this purpose, the device additively combines the measured values for individual withdrawals if the time span between two withdrawals is less than the value t_{diff} , wherein t_{diff} is dynamically selected in a preferred embodiment as a function of the ongoing or previous
25 withdrawal process V_{ext} and as a function of the water temperature T_{act} . Alternatively, t_{diff} can be established as a static parameter. In addition, characteristic time spans for typical activities can be used as a basis for grouping or separating withdrawal processes, e.g., hand-washing $t_{diff} <$
30 120 sec; tooth-brushing $t_{diff} < 240$ sec; showering $t_{diff} < 240$ sec; dish-washing $t_{diff} < 360$ sec. In general it should hold for t_{diff} that $1 \text{ sec} < t_{diff} < 5 \text{ min}$. If a large amount of water is withdrawn for an ongoing withdrawal process, over

10 liters for example, a larger value will tend to be assumed for t_{diff} , such as $2 \text{ sec} < t_{diff} < 15 \text{ min}$. If the device is in metered mode, a new withdrawal process initiated by the user with a high flow quantity per time unit leads, even at a
5 value of $1 \text{ sec} < t_{diff} < 1 \text{ min}$, to an assignment to a new withdrawal process, see Figure 9.

In a preferred embodiment, a counter of the microcontroller 16 serves as a basis for determining the time between two
10 withdrawals, so that a real-time clock can be omitted. Between two withdrawal processes it is possible that the charge stored in the smoothing capacitors of the rectifier module 13 is not sufficient for operating the counter and - if a real-time clock is omitted - no time basis will be
15 available. In this case, the voltage difference at a defined discharging capacitor shortly before the switch-off of a microcontroller 16 and shortly after it is switched back on can be detected with the aid of an analog-digital converter and used to estimate the time difference between the switch
20 off and switch on process. Alternatively, the water temperature can be detected shortly before the switch off and compared to the water temperature shortly after the subsequent switch on. Under the assumption of an approximation to the ambient temperature, it is thus likewise
25 possible to infer the time difference. The methods of detecting the charge state and the temperature can be combined.

The peripheral components 17 support the operation of the
30 previously mentioned components.

An advantageous configuration of the invention is achieved by a division of the measurement unit and the display unit; the

schematic structure as well as the block diagram are shown in Figures 2 and 5. In particular, smaller models of the unit to be placed at the withdrawal site can be achieved in this way, which are easier to integrate into existing withdrawal sites; in addition, the mounting of the display unit in the visual field of the user can be easily achieved. Preferred transmission technologies are optical or radio frequency-based methods, in which data are transferred via amplitude shift keying, abbreviated ASK, differential phase shift keying, abbreviated DPSK, on-off keying, abbreviated OOK, or combined modulation techniques. The energy required to transmit the data can be reduced by varying the amplitude as well as the time intervals between two amplitudes for the encoding of the data.

Particularly due to the limited electrical energy available for transmitting a data packet, the amount of data to be transmitted per packet must be kept as small as possible; at the same time, individual data packets must contain as much information as possible since the number of data packets that can be transmitted per time unit is likewise restricted. Depending on the position of use or the ambient conditions of a device for applying the described method, it can be advantageous to transmit data or data packets that allow a display or calculation of the consumption information without knowledge of the previously transmitted information; this applies particularly if the transmission channel is highly susceptible to interference; or it can be advantageous to transmit data that allow a display or calculation of the consumption information with knowledge of the previously transmitted data, which allows a reduction of the data volume per data packet. This is particularly advantageous if the bandwidth of the transmission system is sharply restricted,

or the display must be updated at a high frequency. In addition, a combination of the two methods can be advantageous, in which, for example, data enabling a display or calculation of the consumption information without
5 knowledge of the previously transmitted information are transmitted alternately with a sequence of data that enable a display or calculation of the consumption information with knowledge of the previously transmitted data. This favors an updating of the display at a higher frequency with reduced
10 data volumes to be transmitted and a simultaneous reduced probability of a display that is erroneous for a long time.

In addition, address information that permits an identification of different measurement modules can be
15 transmitted, or the data sent by different measurement modules can be differentiated based on the data themselves. If for example, counter states or temperature values with sufficient time resolution are continuously transmitted, then assuming continuity of the values, there can be a
20 differentiation based on the values themselves or on the values together with the first or second derivative over time of the curve of the values versus time.

Additionally, the size of a data word, optionally forgoing
25 redundancies for error correction, the accuracy or the time resolution, can be adjusted as a function of the energy available to the transmitter. With a low flow quantity per time unit for example (and an associated relatively low energy available for data transmission), data can be
30 transmitted as 3 to 6 bit-long data packets, and in case of a high flow quantity per time unit (and an associated relatively large amount of energy available for data transmission) data can be transmitted as 4 to 16 bit-long

data packets. The length of the data packets themselves can be used as information available to the receiver for supporting the interpretation of the data packets.

5 In a preferred configuration, synchronization information, such as absolute measurement values, with a word length of 4 or more bits, optionally distributed over several data packets, follows several information items with a relatively short word length of 1 to 16 bits used for updating. In a
10 preferred configuration, information on the volume of the fluid flowing through the apparatus is transmitted as binary data packets according to the above-described method, and the temperature of the fluid is encoded as the time interval between two or more bits to be transmitted. Likewise,
15 information on the temperature of the fluid flowing through the apparatus can be transmitted as binary data packets according to the above-described method, and the volume of the fluid can be encoded as the time interval between two or more bits to be transmitted.

20

Existing methods for determining the resource consumption in the usage of hot or cold water do not promote an easy assessment of personal behavior by the user, since consumption information is not displayed on the level of
25 individual activities. This limits possible learning effects with respect to an economical usage of the resource.

A method has been specified with which the effects on the environment resulting from the consumption, as well as the
30 costs incurred, can be determined and displayed at the site of withdrawal of a fluid or at the location of the controller of the withdrawal process. In particular, related withdrawal processes are recognized with the aid of pattern recognition,

so that an activity-related assessment of the behavior can take place within a short time. The amount of heat energy input into the fluid is determined with the aid of a temperature sensor in the device and an estimation of the temperature before the heat treatment.. If desired, the consumption information is displayed in combination with comparative information or information on the development of the resource consumption over time.

- 10 For a large part of the users, the indication of consumption information on the level of individual activities promotes an economical handling of these very resources and thus reduces the consumption as well as the resulting environmental effects.

Claims

1. Method for determining resource consumption in the usage of a fluid withdrawn at a withdrawal site, in particular
5 water, taking into account a quantity of fluid and temperature values associated with the quantity of fluid, characterized in that

- the quantity of fluid withdrawn at the withdrawal site during a withdrawal unit is acquired to determine the

10 resource consumption, wherein the withdrawal unit

- is based either on the quantity of fluid of an individual withdrawal process

- or on the quantity of fluid of an overall withdrawal process consisting of several individual withdrawal

15 processes,

- in that the overall withdrawal process is taken into consideration if the individual withdrawal processes take place in a time interval that is smaller than a predetermined time window,

20 - in that each individual withdrawal process is subdivided into partial withdrawal processes associated with time units,

- in that an average temperature of the withdrawn fluid is determined as the actual temperature for each partial withdrawal process,

25 - in that a temperature value per time unit is determined from the difference between the actual temperature and a base temperature, and

- in that the resource consumption is determined based on the fluid quantity measured during the withdrawal unit as well as
30 the temperature values determined during the withdrawal unit.

2. Method according to Claim 1,

characterized in that a measured lowest temperature during a number M of prior individual withdrawal processes is determined as the base temperature.

5 3. Method according to Claim 1 or 2,
characterized in that a base value is defined as the base temperature.

10 4. Method according to at least one of the preceding claims,
characterized in that, for water as the fluid, a mean temperature that water has at delivery to a supply network is determined as the base value.

15 5. Method according to at least one of the preceding claims,
characterized in that a time t with $t \leq t_2$, wherein t_2 is selected from the group comprising the average duration of tooth brushing, the average duration of hair washing and the average duration of lathering up, is selected as the time window.

20 6. Method according to at least one of the preceding claims,
characterized in that a time t with $1 \text{ sec} \leq t \leq 5 \text{ min}$ is defined as the time window.

25 7. Method according to at least one of the preceding claims,
characterized in that the consumption information comprises data on the withdrawn volume of water.

30 8. Method according to at least one of the preceding claims,
characterized in that the information comprises data on the quantity of energy expended in providing hot water.

9. Method according to at least one of the preceding claims,

characterized in that the information comprises data on the quantity of energy expended in the preparation of cold water, in particular with respect to the quantity of energy for pumping, cleaning, distribution or processing, or a
5 combination thereof.

10. Method according to at least one of the preceding claims, characterized in that the information comprises data on the total quantity of energy expended in providing the withdrawn
10 water.

11. Method according to at least one of the preceding claims, characterized in that the information comprises data on the resulting greenhouse gas emissions.
15

12. Method according to at least one of the preceding claims, characterized in that the display alternates between the information listed in Claims 2-6, or a selection thereof.

20 13. Method according to at least one of the preceding claims, characterized in that individual information items listed in Claims 2-9 are selected automatically based on the flow quantity, the change over time of the flow quantity or the water temperature.

25 14. Method according to at least one of the preceding claims, characterized in that the water flow through the device drives a turbine wheel that is itself magnetized or is rigidly connected to permanent magnets, whereby an
30 alternating magnetic field is generated in one or more coils during a rotational motion of the turbine wheel and thus an AC voltage is generated whose curve over time is applied as

an indicator for the flow amount and that additionally supplies the device with electrical energy.

15. Method according to at least one of the preceding claims,
5 characterized in that no external electrical energy source or internal battery is needed for operation.

16. Method according to at least one of the preceding claims,
10 characterized in that a supply voltage is limited with the aid of light-emitting diodes that are applied for lighting the display.

17. Method according to at least one of the preceding claims,
15 characterized in that the diodes for lighting the display can transmit data gathered by the device to an external device with the aid of data modulation methods.

18. Method according to at least one of the preceding claims,
20 characterized in that the cost-relevant and the environmentally relevant information from previous measurements or from other user groups is related to the measured values in order to facilitate comparisons.

19. Method according to at least one of the preceding claims,
25 characterized in that trends in user behavior are recognized and displayed.

20. Method according to at least one of the preceding claims,
30 characterized in that the user behavior can be classified into efficiency classes.

21. Method according to at least one of the preceding claims,

characterized in that the method can be combined with water stream regulators and flow limiters.

22. Arrangement for determining resource consumption,
5 comprising

- a generator (11) for generating an output voltage by means of a fluid, water in particular, flowing through the arrangement during a withdrawal unit, and

- an electronics component (13, 16, 17) that is designed

10 - to determine from the output voltage of the generator (11) a fluid quantity of the fluid flowing through the arrangement during the withdrawal unit, wherein the withdrawal unit is based on an overall withdrawal process composed of several individual withdrawal processes if
15 the individual withdrawal processes take place in a time interval that is smaller than a predetermined time window, and

- to provide a signal indicating the resource consumption as a function of the output voltage of the generator
20 (11).

23. Arrangement according to Claim 22,

in which the arrangement is designed to determine the fluid quantity of a first and a second individual withdrawal
25 process separately as the fluid quantity of the withdrawal unit, if the first and the second withdrawal process take place in a time interval that is larger than the predetermined time window.

30 24. Arrangement according to Claim 22 or 23,

comprising a temperature sensor (12) for providing a temperature signal that depends on a temperature of the fluid, wherein the electronics component (13, 16, 17) is

designed to provide the signal for indicating the resource consumption as a function of the temperature signal and the output voltage of the generator (11).

5 25. Arrangement according to Claim 24,
in which the electronics component (13, 16, 17) is designed
to provide the signal for indicating the resource consumption
also as a function of a base temperature, and a measured
lowest temperature during a number M of preceding individual
10 withdrawal processes, or a base value is defined as the base
temperature.

26. Arrangement according to one of Claims 22-25,
in which the electronics component comprises a
15 microcontroller (16) that is designed to combine individual
withdrawal processes into an overall withdrawal process by
means of an evaluation of a duration of individual withdrawal
processes and the time intervals between two or more
individual withdrawal processes.

20 27. Arrangement according to one of Claims 22-26,
in which the generator (11) is designed to generate the
output voltage of the generator (11) in such a manner that
the output voltage of the generator (11) can operate the
25 electronics component (13, 16, 17).

28. Arrangement according to one of Claims 22-27,
in which the generator (11) comprises a turbine wheel (111)
that is designed to be set into rotational motion by the
30 fluid flowing through the arrangement.

29. Arrangement according to Claim 28,

in which the turbine wheel (111) is produced from magnetized material or is connected to at least one magnet (113).

30. Arrangement according to Claim 28 or 29,
5 comprising an interior housing (151), wherein the generator (11) comprises at least one coil (114) and the at least one coil (114) is mounted on a side of the interior housing (151) facing away from the fluid such that an alternating magnetic field flows through the at least one coil (114) during the
10 rotational movement.

31. Arrangement according to one of Claims 22-30,
comprising a housing (151, 152) that has a thread or a coupler designed for connection to a water faucet, a mixing
15 tap, a shower head, a shower hose, a water line, or a garden hose.

32. Arrangement according to one of Claims 22-31,
comprising a display module (14) for a display of the signal
20 indicating the resource consumption.

33. Arrangement according to one of Claims 22-32,
comprising a rectifier module (13) for generating a supply voltage (VDD) from the output voltage of the generator (11).
25

34. Water withdrawal device, in particular a water faucet, shower head, shower hose, mixing tap, garden hose or water line comprising an arrangement according to one of Claims 22-32.